CLAIMS

What is claimed is:

1. A two-dimensional scanner comprising:
   a) a base;
   b) an outer frame rotatably attached to the base for rotation about a first axis substantially parallel to a plane containing the outer frame and/or the base;
   c) an inner part rotatably attached to the outer frame for rotation about a second axis substantially parallel to a plane containing the inner part and/or the outer frame;
   d) a first set of comb fingers attached to the outer frame; and
   e) a second set of comb fingers attached to the base, wherein the first and second sets of comb fingers interdigitate at some rotation of the outer frame relative to the base about the first axis.

2. The scanner of claim 1, further comprising means for applying a voltage between the first and second set of comb fingers, whereby the comb fingers may act as a comb-drive actuator.

3. The scanner of claim 2, further comprising means for applying a constant biasing force between the outer frame and the base.

4. The scanner of claim 2, further comprising means for sensing an angular position of the outer frame relative to the base.

5. The scanner of claim 4, wherein the means for sensing angular position are chosen from the

group consisting of gap-closing electrodes and piezoresistive sensors.

6. The scanner of claim 4, wherein the means for sensing angular position comprises a capacitance sensor electrically coupled between the first and second sets of comb fingers, whereby the comb fingers may act as both a comb-drive actuator and a sensor.

7. The scanner of claim 1, further comprising means for sensing an angular position of the outer frame relative to the base.

8. The scanner of claim 7, wherein the means for sensing angular position includes a capacitance sensor electrically coupled between the first and second sets of comb fingers.

9. The scanner of claim 7, further comprising drive means for rotating the outer frame relative to the base.

10. The scanner of claim 9, wherein the drive means is chosen from the group consisting of gap-closing electrodes, magnetic drives, and piezo drives.

11. The scanner of claim 1, further comprising:

e) a third set of comb fingers attached to the inner part; and

f) a fourth set of comb fingers attached to the outer frame, wherein the third and fourth sets of comb fingers interdigitate at some rotation of the inner part relative to the outer frame about the second axis.

12. The scanner of claim 11, further comprising:

g) means for applying a voltage between the first and second sets of comb fingers, whereby the first and second sets of comb fingers may act as a comb-drive actuator; and

h) means for applying a voltage between the third and fourth sets of comb fingers, whereby the third and fourth sets of comb fingers may act as a comb-drive actuator.

13. The scanner of claim 12, further comprising:

g') means for measuring a capacitance between the first and second sets of comb fingers, whereby the first and second sets of comb fingers may act as both a comb-drive actuator and a position sensor; and

h') means for measuring a capacitance between the third and fourth sets of comb fingers, whereby the third and fourth sets of comb fingers may act as both a comb-drive actuator and a position sensor.

14. The scanner of claim 12, further comprising:

g'') means for measuring a capacitance between the first and second sets of comb fingers, whereby the first and second sets of comb fingers may act as a position sensor; and

h'') means for measuring a capacitance between the third and fourth sets of comb fingers, whereby the third and fourth sets of comb fingers may act as a position sensor.

15. The scanner of claim 14, further comprising drive means for rotating the inner part relative to the outer frame.

16. The scanner of claim 15, wherein the drive means is chosen from the group consisting of gap-closing electrodes, magnetic drives, and piezo drives.

17. The scanner of claim 14, further comprising drive means for rotating the outer frame relative to the base.

18. The scanner of claim 17, wherein the drive means is chosen from the group consisting of gap-closing electrodes, magnetic drives, and piezo drives.

19. The scanner of claim 1, wherein the outer frame is rotatably attached to the base by means selected from the group consisting of torsional flexures, cantilever-like flexures, serpentine flexures, and pin-and-staple type hinges.

20. The scanner of claim 19, wherein the torsional flexures have cross-sections selected from the group consisting of rectangular cross-section, I-shaped cross-section, and T-shaped cross-section.

21. The scanner of claim 1, wherein the inner part is rotatably attached to the outer frame by means selected from the group consisting of torsional flexures, cantilever-like flexures, serpentine flexures, and pin-and-staple type hinges.

22. The scanner of claim 21, wherein the torsional flexures have cross-section selected from the group consisting of rectangular cross-section, I-shaped cross-section, and T-shaped cross-section.

23. A two-dimensional scanner comprising:

a) a base;

b) an outer frame rotatably attached to the base for rotation about a first axis substantially parallel to a plane containing the outer frame and/or the base;

c) an inner part rotatably attached to the outer frame for rotation about a second axis substantially parallel to a plane containing the outer frame and/or the base;

d) a first set of comb fingers attached to the inner part; and

e) a second set of comb fingers attached to the outer frame, wherein the first and second sets of comb fingers interdigitate at some rotation of the inner part relative to the outer frame about the second axis.

24. The scanner of claim 23, further comprising means for applying a voltage between the first and second set of comb fingers, whereby the comb fingers may act as a comb-drive actuator.

25. The scanner of claim 24, further comprising means for applying a constant biasing force between the inner part and the outer frame.

26. The scanner of claim 24, further comprising means for sensing an angular position of the inner part relative to the outer frame.

27. The scanner of claim 26, wherein the means for sensing angular position are chosen from the group consisting of gap-closing electrodes and piezoresistive sensors.

28. The scanner of claim 26, wherein the means for measuring angular position comprises a capacitance sensor electrically coupled between the first and second sets of comb fingers, whereby the comb fingers may act as both a comb-drive actuator and a sensor.

29. The scanner of claim 23, further comprising means for sensing an angular position of the inner part relative to the outer frame.

30. The scanner of claim 29, wherein the means for sensing angular position includes a capacitance sensor electrically coupled between the first and second sets of comb fingers.

31. The scanner of claim 29, further comprising drive means for rotating the outer frame relative to the base.

32. The scanner of claim 31, wherein the drive means is chosen from the group consisting of gap-closing electrodes, magnetic drives, and piezo drives.

33. The scanner of claim 23, wherein the outer frame is rotatably attached to the base by means selected from the group consisting of torsional flexures, cantilever-like flexures, serpentine flexures, and pin-and-staple type hinges.

34. The scanner of claim 33, wherein the torsional flexures have cross-sections selected from the group consisting of rectangular cross-section, I-shaped cross-section, and T-shaped cross-section.

35. The scanner of claim 23, wherein the inner part is rotatably attached to the outer frame by means selected from the group consisting of torsional flexures, cantilever-like flexures, serpentine flexures, and pin-and-staple type hinges.

36. The scanner of claim 35, wherein the torsional flexures have cross-section selected from the group consisting of rectangular cross-section, I-shaped cross-section, and T-shaped cross-section.

37. A fiber-optic switch comprising:

a) an array of input optical fibers;

b) one or more arrays of mirrors for deflecting light from one or more input optical fibers, wherein one or more mirrors in the one or more arrays includes a two-dimensional scanner; and

c) an array of output optical fibers for coupling light emerging from the one or more arrays of mirrors;

wherein the two-dimensional scanner comprises:

i) a base;

ii) an outer frame rotatably attached to the base for rotation about a first axis substantially parallel to a plane containing the outer frame and/or the base;

iii) an inner part rotatably attached to the outer frame for rotation about a second axis substantially

parallel to a plane containing the outer frame and/or the base;

iv) a first set of comb fingers attached to the outer frame; and

v) a second set of comb fingers attached to the base, wherein the first and second sets of comb fingers interdigitate at some rotation of the outer frame relative to the base about the first axis.

38. The switch of claim 37, wherein the one or more arrays of mirrors individually steer light from the input optical fibers to the output optical fibers.

39. The switch of claim 37, wherein the input optical fibers and output optical fibers are terminated with microlenses.

40. The switch of claim 37, wherein the inner part includes a mirror.

41. The switch of claim 37, further comprising means for applying a voltage between the first and second set of comb fingers, whereby the first and second sets of comb fingers may act as a comb-drive actuator.

42. The switch of claim 37, further comprising means for sensing a capacitance between the first and second comb fingers, whereby the first and second sets of comb fingers may act as a position sensor for sensing an angular position of the outer frame relative to the base.

43. The switch of claim 42, further comprising means for applying a voltage between the first and second set of comb fingers, whereby the first and second sets of comb fingers may act as both

a comb-drive actuator and an angular position sensor.

44. The optical switch of claim 37, further comprising:

e) a third set of comb fingers attached to the inner part; and

f) a fourth set of comb fingers attached to the outer frame, wherein the third and fourth sets of comb fingers interdigitate at some rotation of the inner part relative to the outer frame about the second axis.

45. An optical switch, comprising:

a) an array of input optical fibers;

b) one or more arrays of mirrors for deflecting light from one or more input optical fibers, wherein one or more mirrors in the one or more arrays includes a two-dimensional scanner; and

c) an array of output optical fibers for coupling light emerging from the one or more arrays of mirrors;

wherein the two-dimensional scanner comprises:

i) a base;

ii) an outer frame rotatably attached to the base for rotation about a first axis substantially parallel to a plane containing the outer frame and/or the base;;

iii) an inner part rotatably attached to the outer frame for rotation about a second axis substantially parallel to a plane containing the outer frame and/or the base;

iv) a first set of comb fingers attached to the inner part; and

v) a second set of comb fingers attached to outer frame, wherein the first and second sets of comb fingers interdigitate at some rotation of the

inner part relative to the outer frame about the second axis.

46. The switch of claim 45, wherein the one or more arrays of mirrors individually steer light from the input optical fibers to the output optical fibers.

47. The switch of claim 45, wherein the input optical fibers and output optical fibers are terminated with microlenses.

48. The switch of claim 45, wherein the inner part includes a mirror.

49. The switch of claim 45, further comprising means for applying a voltage between the first and second set of comb fingers, whereby the first and second sets of comb fingers may act as a comb-drive actuator.

50. The switch of claim 45, further comprising means for sensing a capacitance between the first and second comb fingers, whereby the first and second sets of comb fingers may act as a position sensor for sensing an angular position of the outer frame relative to the base.

51. The switch of claim 50, further comprising means for applying a voltage between the first and second set of comb fingers, whereby the first and second sets of comb fingers may act as both a comb-drive actuator and an angular position sensor.